Willow Boulevard/ A-Site Operable Unit:

Post-Closure Groundwater Monitoring Program

September 13, 2012

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Overview of Presentation, Statement of Objectives

Changes to Michigan Part 201 – effective June 20, 2012 – provide new options for demonstrating compliance with Michigan Act 451 Part 201

Key updates include determination of GSI pathway relevance and new alternatives for post-closure groundwater monitoring

Presentation objectives:

- Present overview of new provisions of Part 201
- Review Site-specific conditions & relevance of GSI pathway
- Discuss proposed approach to documenting effectiveness per requirements of the OU-specific Consent Decree while demonstrating compliance with Part 201

Changes to Part 201

Summary of Key Changes to Part 201

- All Part 201 rules related to GSI have been rescinded
  - Exception is rules related to establishing generic cleanup criteria and screening levels
- Relevance of GSI pathway to be assessed **before** assuming monitoring is necessary
- Response activity beyond evaluation not always required for venting groundwater, even if there are detections of constituents above GSI criteria

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Alternative Approaches to Demonstrating Compliance with Part 201 *(individually or in combination)*

- Meet Generic GSI Criteria
- Apply for variance from surface water quality standards
- Request mixing zone determination
- Propose alternative monitoring points
- Develop site-specific criteria (may include biological criteria)

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Alternative Approaches to Demonstrating Compliance with Part 201
(individually or in combination, cont'd)

- Perform modeling demonstration
- Demonstrate that GSI pathway is not relevant
- Demonstrate *de minimis* effect on surface water body
- Demonstrate technical impracticability
- Demonstrate facility-specific evidence of natural attenuation

Installing a groundwater monitoring well in the former Plainwell Impoundment

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Key Implications of the Part 201 Changes

- No response activity necessary if venting groundwater has no effect or *de minimis* effect on surface water body
- GSI monitoring well data are NOT necessary to make this determination
  - Other information – including existing data, professional judgment, and fate & transport modeling – can be used
- Post-closure assessment/monitoring approach for WB/A-Site OU can be developed to take advantage of the changes to Part 201

Take Away Messages:

- Demonstrating compliance with Part 201 has fundamentally changed
- Starting point is different – no longer assumed that long-term monitoring must be part of post-closure program
- Provides opportunity to apply lessons learned at other Landfill OUs and River OU and move forward with an approach that documents effectiveness of the remedy consistent with WB/A-OU Consent Decree while demonstrating compliance with Part 201

Determining Relevance of GSI Pathway at Willow Boulevard/A-Site OU

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Relevance of GSI Pathway

- GSI pathway relevant when hazardous substance in groundwater is reasonably expected to vent to surface water in concentrations that exceed generic GSI criteria [§324.20120e(3)]
- Relevance to be determined based on RI data and/or best professional judgment
- Key site-specific factors considered in assessing relevance at WB/A-Site OU include:
  - Chemical and physical properties of PCBs
  - Groundwater quality at WB/A-Site OU
  - Data/information from other Landfill OUs and River OU collected over the past decade
  - Hydraulic connectivity between landfill and underlying aquifer
  - Modeling of PCB flux

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Remember:

- Assessing the relevance of the GSI pathway is the first step in determining the scope of the post-closure program
- GSI pathway determination:
  - "Response activity beyond evaluations shall not be required if venting groundwater has no effect or only a *de minimis* effect on a surface water body" [§324.20120e(14)]
  - Existing data and/or best professional judgment (which may include modeling) can be used to evaluate whether effects are *de minimis* [§324.20120e(3)] [§324.20120e(4)(b)]

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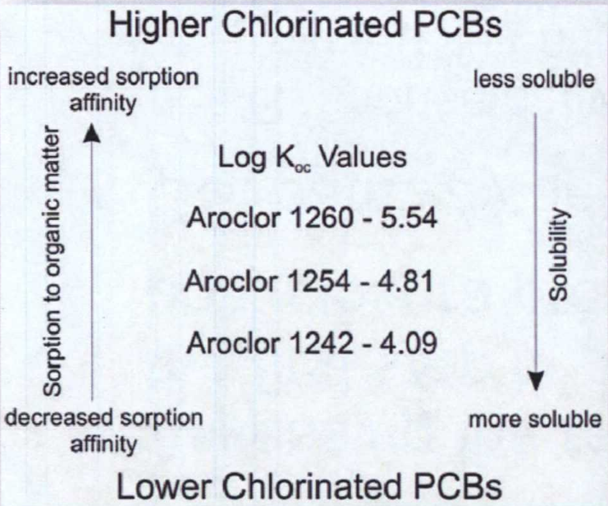
Chemical and Physical Properties of PCBs



- **PCBs are hydrophobic, low miscibility in water (Chou and Griffin 1986)**
- **Decreasing solubility in water with increasing chlorination (Chou and Griffin 1986)**
- **Soluble in most organic solvents and oils (Erickson 1997)**
- **Adhere to particles, increasing adsorption with increasing chlorination (Chou and Griffin 1986)**
- **High organic carbon partition coefficient (K_{oc}) values (Versar, Inc. 1998)**
- **Due to strong affinity to organic carbon, PCBs are quite immobile in soils and sediments (USEPA 1990)**
- **Generally do not leach to groundwater (ATSDR 2000; MDEQ 2011)**

➢ ***PCBs in the Landfill OUs are not likely to move into groundwater or surface water***

Chemical and Physical Properties of Paper Residuals

- Landfill OUs are "monofills" – primarily paper-making residuals with high clay content
- Identified as organic clay or silt in Unified Soil Classification System
- High organic content (27 - 70% by weight)
- NCASI conducted laboratory studies and field tests to assess hydraulic conductivity (K) of residuals (Maltby and Eppstein 1996)
  - Laboratory studies: average K of 10^{-6} cm/s
  - Field studies: average K of $10^{-7} – 10^{-8}$ cm/s
- K decreases as residuals consolidate (Moo-Young and Zimmie 1996)
- From 1990 to 2004 more than 29 industrial and municipal landfills were closed using residuals as the hydraulic barrier layer (NCASI 2005)

➢ *PCBs in the Landfill OUs are not likely to move into groundwater or surface water*

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Treated Water from Paper Residuals

- A-Site wastewater treatment plant treats combined surface water runoff, perched water runoff, & wash water (vehicles, PPE) during construction

Statistical Data Summary for Onsite Wastewater Treatment System

Sample Type	Range (µg/L)	Frequency of Detection	Summary Statistics (µg/L)		Total Number of Samples that Exceed			
			Geometric Mean	Median	0.2 (µg/L)	0.5 (µg/L)	1.0 (µg/L)	5.0 (µg/L)
Influent	0.053 U - 4	85% (11/13)	0.33	0.40	8 (62%)	4 (31%)	2 (15%)	0 (0%)

Notes:
1. Data include wastewater treatment samples collected weekly between March 8, 2012 and July 20, 2012 at A-Site.
2. One-half the detection limit was used as a proxy concentration for non-detects.
3. Parent/duplicate samples were averaged prior to analysis.

- One-third of the samples from this "worst-case" water contain PCB concentrations less than GSI criterion, and only 15% (2 of 13) exceed 1 µg/L

➢ ***"Worst-case" seep / runoff / wash water collected during construction activities contain only low concentrations of PCBs***

Groundwater Quality at WB/A-Site OU

- **RI PCB Data**: No detections of PCBs at Willow Boulevard, PCBs detected in 11/22 samples at A-Site – no exceedances of GSI criterion
- **Other Analytes:** Naturally-occurring inorganics commonly detected – geomean/ median of all were generally below or within same order of magnitude as GSI criteria
- All samples collected upgradient of the actual GSI – therefore, even minor mixing or attenuation would result in compliance

➢ *PCBs are not present above GSI criterion; geomean/median of other constituents generally within order of magnitude of GSI criteria*

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Precedence at other OUs

- Monitoring programs at other Landfill OUs and Area 1 of River OU provide important precedence for WB/A OU
- 12th St OU and KHL OU, in particular, represent similar conditions to WB/A OU with respect to:
  - Large mass of PCB-containing residuals in disposal area
  - Hydrogeology/ hydraulic connectivity of residuals to aquifer
  - Direction of groundwater movement
  - Proximity to river
  - Groundwater quality

➢ *The results of monitoring at other OUs should be used to guide and inform approach used at WB/A OU*

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Reduction of Groundwater Monitoring Programs at other OUs

- **King Highway Landfill OU**: program scaled back after 8 years of data indicate no detections above GSI criterion – all non-PCB analyses eliminated, PCB monitoring frequency reduced to annual
- **12th Street Landfill OU:** no upgradient monitoring after three quarters, program review after two years (results to date – no PCB detections)
- **Former Plainwell Impoundment:** program ended three quarters early after no PCB detections
- **Findings of the Area 1 SRI Report:** groundwater is not a PCB source or transport pathway to the river

➢ *Groundwater monitoring programs are evolving based on an adaptive management approach – groundwater in landfills and floodplains is not a source of PCBs*

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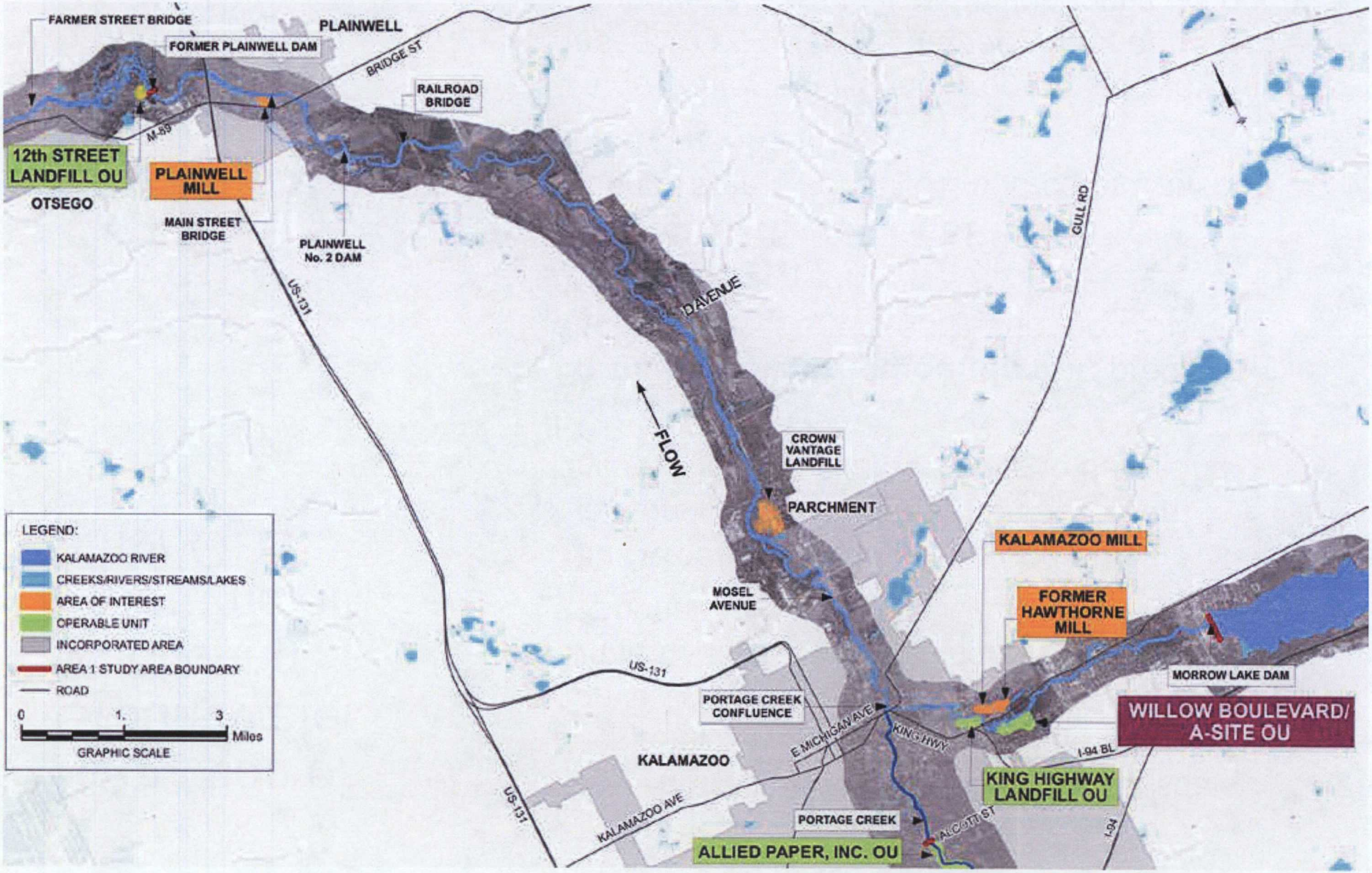
General Location Map



King Highway Landfill Operable Unit

- 400,000 cy of residuals disposed in landfill along the River, approximately 1,100 feet downstream of WB/A OU
- Monitoring program reviewed after nearly 8 years
- Data from 15 wells (500 unfiltered samples, approximately 10,000 individual constituent analyses)
- GSI criteria never exceeded for VOCs or SVOCs, and only infrequently for general water quality parameters
- PCBs detected in 6% (34 of 582) of downgradient well samples, ***but never above GSI criterion***
- Monitoring program revised to eliminate VOCs, SVOCs, general water quality parameters – only PCBs retained
- Sampling frequency for PCBs reduced from quarterly to once per year

12th Street Landfill Operable Unit

- Landfill OU on Kalamazoo River where 209,000 cy of residuals were disposed
- Post-closure monitoring began in 2011 – includes 15 wells installed upgradient, lateral to, and downgradient
  - Upgradient wells to be monitored for first two quarters, then as needed
  - Downgradient wells monitored quarterly/semi-annually for first two years
- Analyses of unfiltered samples for PCBs, TCL VOCs and SVOCs, TAL inorganics, dioxins/furans, general water quality parameters
- Data from first three quarters: PCB detected ***below GSI criterion*** in 2 of 45 samples; GSI criteria exceeded in downgradient wells for arsenic (1 of 26 samples), cyanide (2 of 26 samples), mercury (4 of 39 samples)
- SOW includes provision to reduce frequency of monitoring after two years

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The River Operable Unit

Former Plainwell Impoundment monitoring program ended after five quarters (compared to the planned eight) when all 75 groundwater (unfiltered) samples were non-detect for PCBs

Key conclusion included in Area 1 SRI Report:

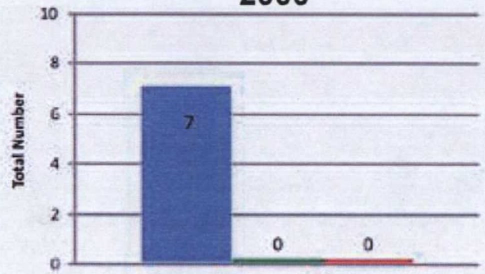
> ***At the Site in general and Area 1 in particular, groundwater is neither a significant transport pathway nor an important source of PCBs to river surface water or sediments***

Result: Groundwater was eliminated as medium of concern

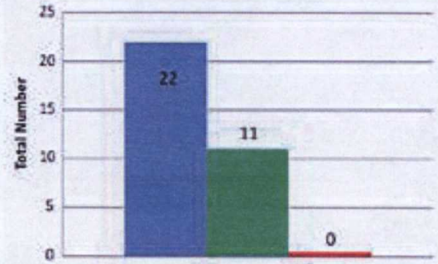
Landfill OU Groundwater PCB Sampling Results

LEGEND
- Total Samples
- Detects
- Detects > GSI Criterion

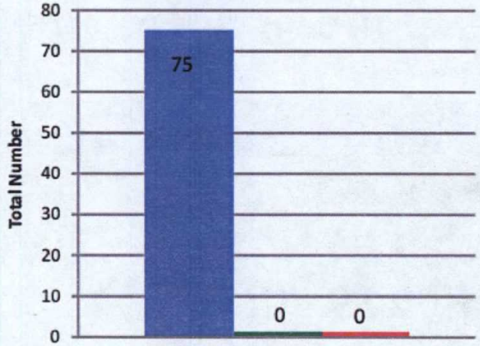
Willow Boulevard Landfill – Not Closed 2000



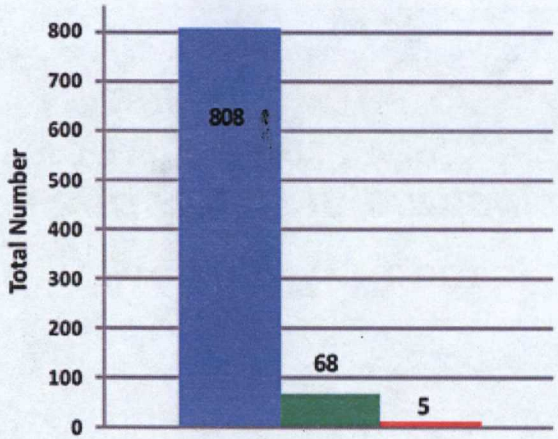
A-Site Landfill – Not Closed 2000



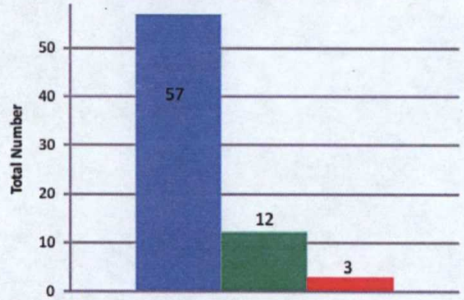
Former Plainwell Impoundment – 2009 – 2010



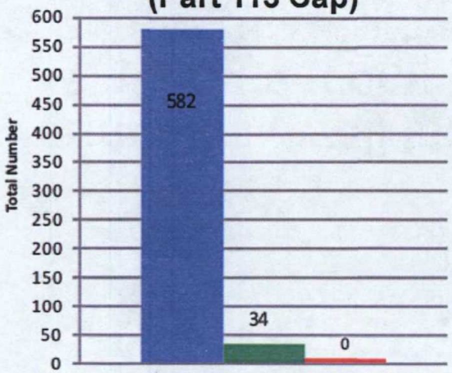
All Locations



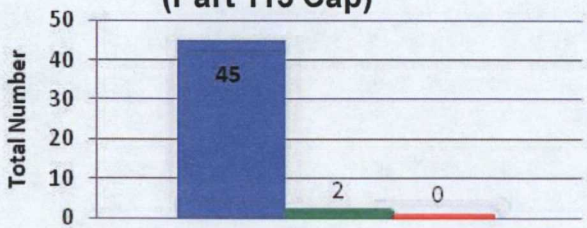
Allied Paper, Inc. Landfill OU Groundwater – Not Closed 2002 - 2003



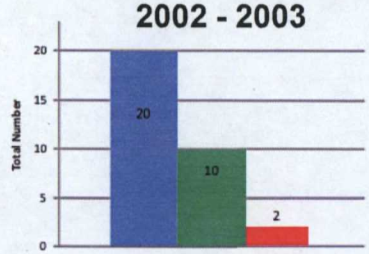
King Highway Landfill OU 2003 – 2011 (Part 115 Cap)



12th Street Landfill OU 2011 – 2012 (Part 115 Cap)



Allied Paper, Inc. Landfill OU Seeps – Not Closed 2002 - 2003



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Non-PCB Groundwater Sampling Results from WB/A-Site OU

Parameter	Detections / N	Range	Geometric Mean	Median	GSI Criterion	GSI Criterion Exceedances
A-Site Groundwater (1993-1994 Remedial Investigation) – No Part 115 Cap						
Aldrin (ug/L)	1/16 (6.2%)	ND(0.050) - 0.028	0.026	0.025	0.010	1/16 (6.2%)
Arsenic (mg/L)	14/16 (87.5%)	ND(0.00099) - 0.10	0.0039	0.0025	0.010	4/16 (25%)
Arsenic (Dissolved) (mg/L)	13/16 (81.2%)	ND(0.00099) - 0.090	0.0041	0.0033	0.010	4/16 (25%)
Cyanide (mg/L)	9/16 (56.2%)	ND(0.010) - 0.022	0.0095	0.012	0.0052	9/16 (56.2%)
bis(2-Ethylhexyl)phthalate (µg/L)	1/16 (6.2%)	ND(10) - 49	8.1	5.3	25	1/16 (6.2%)
4-Methylphenol	9/16 (56.2%)	ND(10) - 44	5.2	5.0	71	0/16 (0%)
Willow Boulevard Groundwater (1993-1994 Remedial Investigation) – No Part 115 Cap						
Aldrin (ug/L)	0/7 (0.0%)	ND(0.050) - ND(0.056)	--	--	0.010	0/16 (0%)
Arsenic (mg/L)	4/7 (57.1%)	ND(0.00099) - 0.022	0.0017	0.0019	0.010	1/7 (14.3%)
Arsenic (Dissolved) (mg/L)	6/7 (85.7%)	ND(0.0010) - 0.019	0.0033	0.0027	0.010	1/7 (14.3%)
Cyanide (mg/L)	2/7 (28.6%)	ND(0.010) - 0.041	0.0071	0.0050	0.0052	2/7 (28.6%)
bis(2-Ethylhexyl)phthalate (µg/L)	0/7 (0.0%)	ND(10) - ND(44)	--	--	25	0/7 (0%)
4-Methylphenol	2/7 (28.6%)	ND(10) - 13	4.5	5.0	71	0/7 (0%)

Notes:
1. Parameters identified by MDEQ (Zakrzewski, December 13, 2011).
2. GSI criteria from MDEQ Operational Memorandum 1 Attachment 1, document release date March 25, 2011. Note that GSI criteria and associated rules are currently being reevaluated by Collaborative Stakeholder Initiative (CSI) team members.

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Non-PCB Sampling Results from Other Landfill OUs

Parameter	Detections / N	Range	Geometric Mean	Median	GSI Criterion	GSI Criterion Exceedances
12th Street Landfill Groundwater (2011-2012) – Closed with Part 115 Cap						
Arsenic (mg/L)	28/30 (93.3%)	ND(0.00050) - 0.015	0.00036	0.00025	0.010	1/30 (3.3%)
Cyanide (mg/L)	6/30 (20.0%)	ND(0.010) - 0.0090	0.0052	0.0050	0.0052	4/30 (13.3%)
Mercury (mg/L)	17/45 (37.8%)	ND(0.0000010) - 0.000020	0.0000039	0.00000085	0.0000013	4/45 (8.9%)
Allied OU Groundwater (2002-2003) – No Part 115 Cap						
Arsenic (mg/L)	21/65 (32.3%)	ND - 0.14	0.036	0.037	0.01	21/65 (32.3%)
Cyanide (mg/L)	3/65 (4.6%)	ND - 0.019	0.014	0.013	0.0052	3/65 (4.6%)
Manganese (mg/L)	58/65 (89.2%)	ND - 6.2	0.34	0.29	1.3	8/65 (12.3%)
Silver (mg/L)	1/65 (1.5%)	ND - 0.0017	--	--	0.0002	1/65 (1.5%)
Zinc (mg/L)	6/65 (9.2%)	ND - 5.3	1.0	0.86	0.38	5/65 (7.7%)
King Highway Landfill Groundwater (2003-2010) – Closed with Part 115 Cap						
Thallium (mg/L)	15/462 (3.2%)	ND(0.00050) - 0.0087	0.0020	0.0026	0.0037	3/462 (0.6%)
Zinc (mg/L)	17/46 (37.0%)	ND(0.0014) - 21	0.0044	0.0020	0.38	3/46 (6.5%)

Notes:
1. GSI criteria from MDEQ Operational Memorandum 1 Attachment 1, document release date March 25, 2011.

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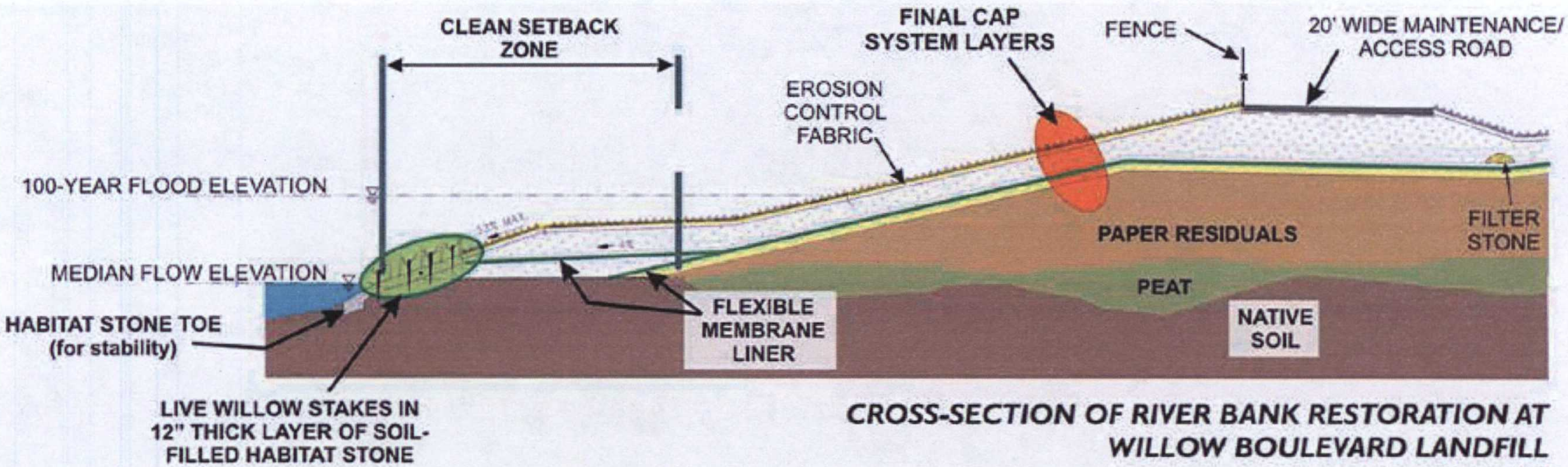
Hydraulic Connectivity to Aquifer

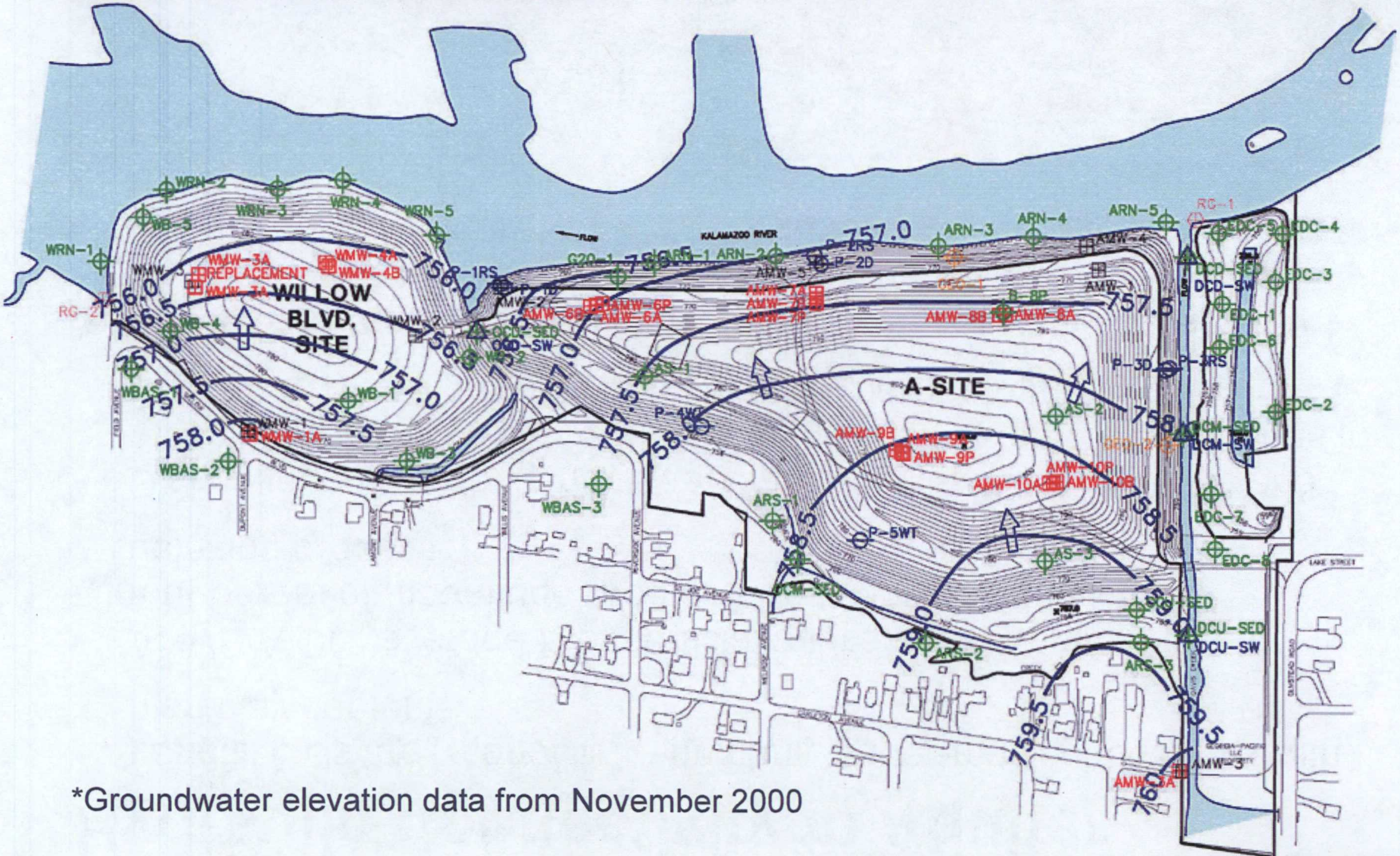
- Landfill OUs are “monofills” – primarily paper-making residuals with high clay content
- At WB/A OU, average K of surficial aquifer is 10^{-3} cm/s – two to four orders of magnitude greater than typical residuals from deinking process
- Discontinuous, organic-rich peat that underlies most of A-Site and much of Willow Boulevard ranges in thickness from several inches to 6 feet provides a physical and chemical barrier to transport of PCBs

➢ ***There is minimal hydraulic connection of residuals to aquifer***



CROSS-SECTION OF RIVER BANK RESTORATION AT WILLOW BOULEVARD LANDFILL (not to scale)

Willow Boulevard/A-Site Operable Unit
Groundwater Contours



*Groundwater elevation data from November 2000

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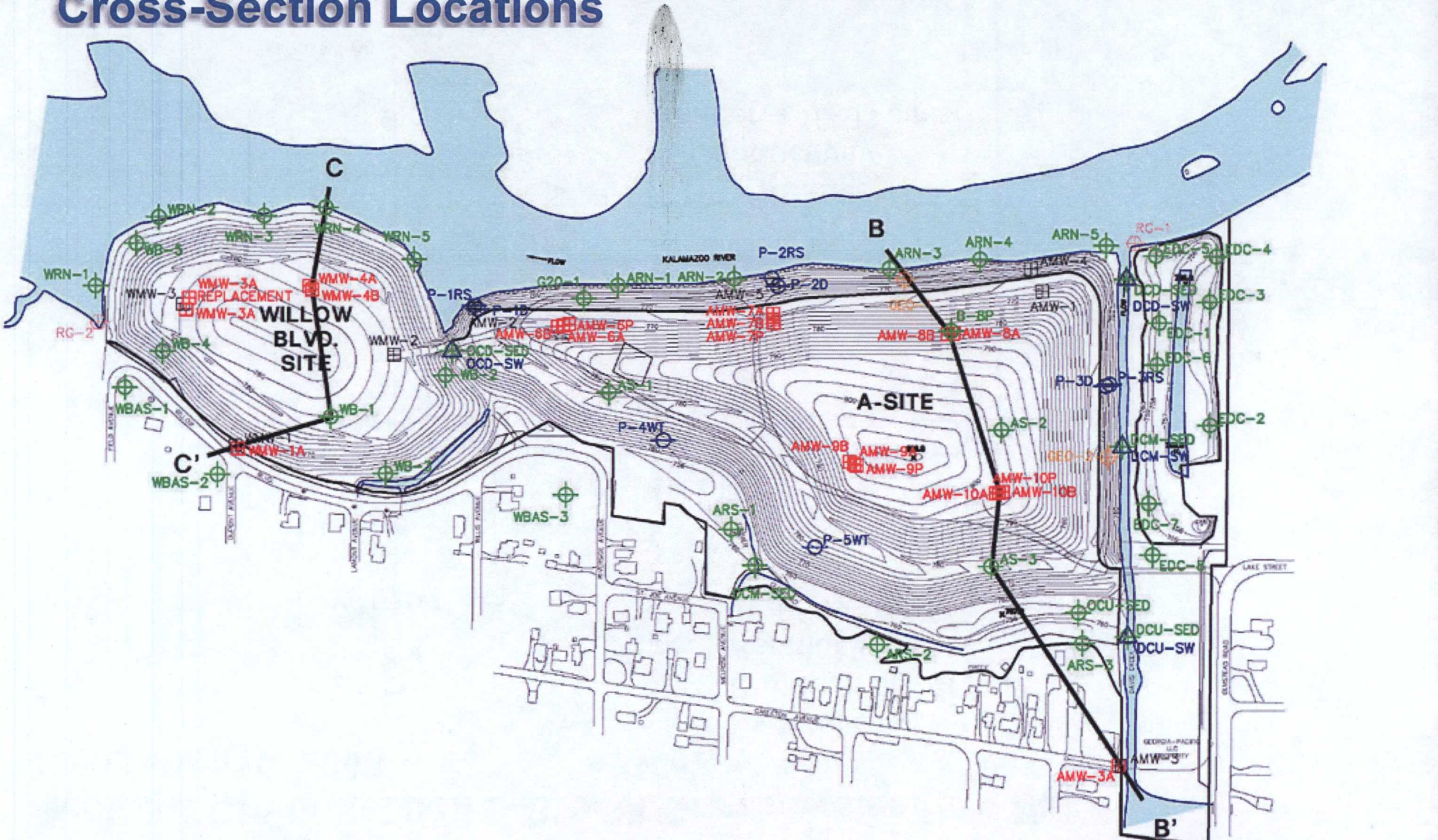
Willow Boulevard/A-Site Operable Unit Cross-Section Locations



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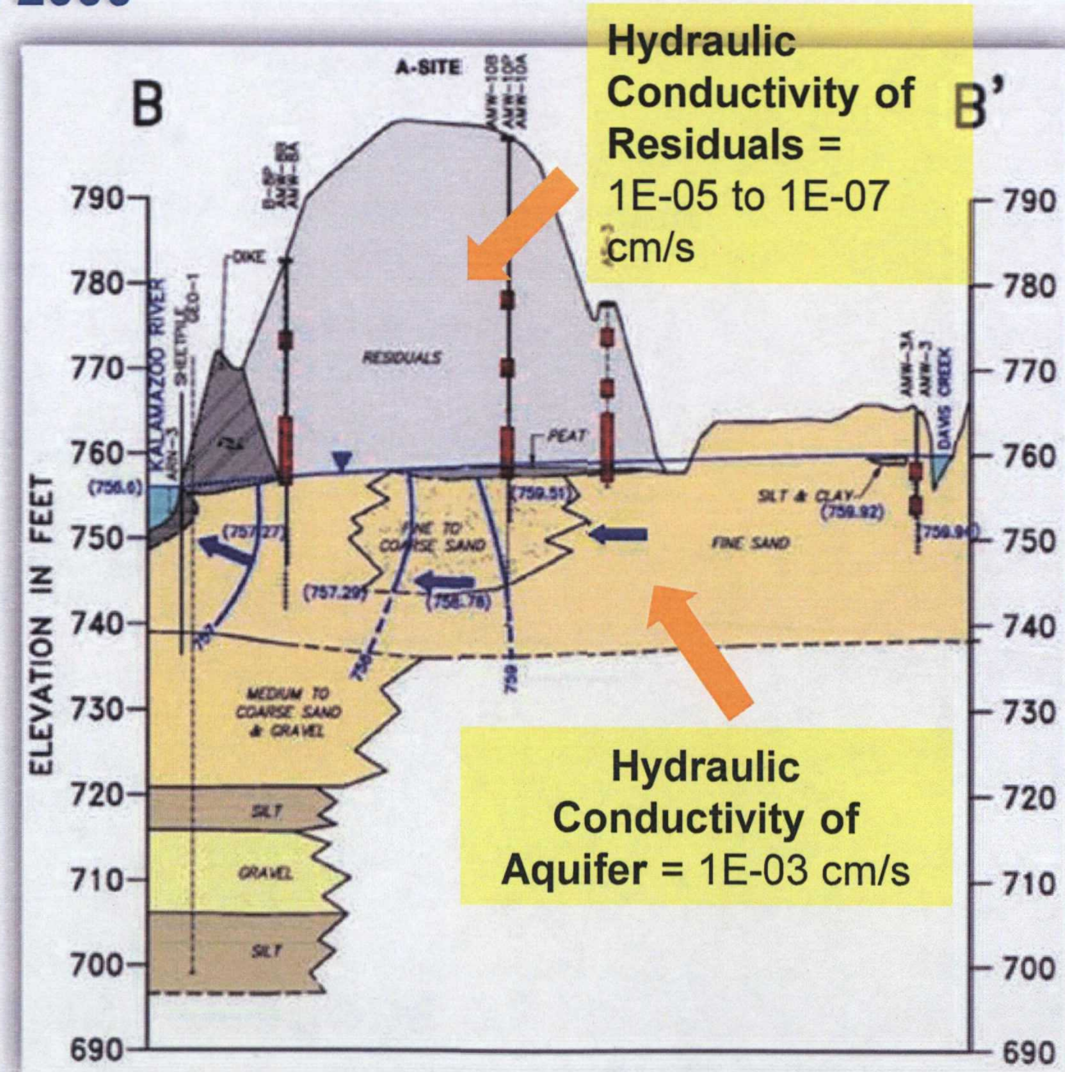
Willow Boulevard/A-Site Operable Unit
Geologic Cross-Section B-B' with Groundwater Flow Net
November 10, 2000



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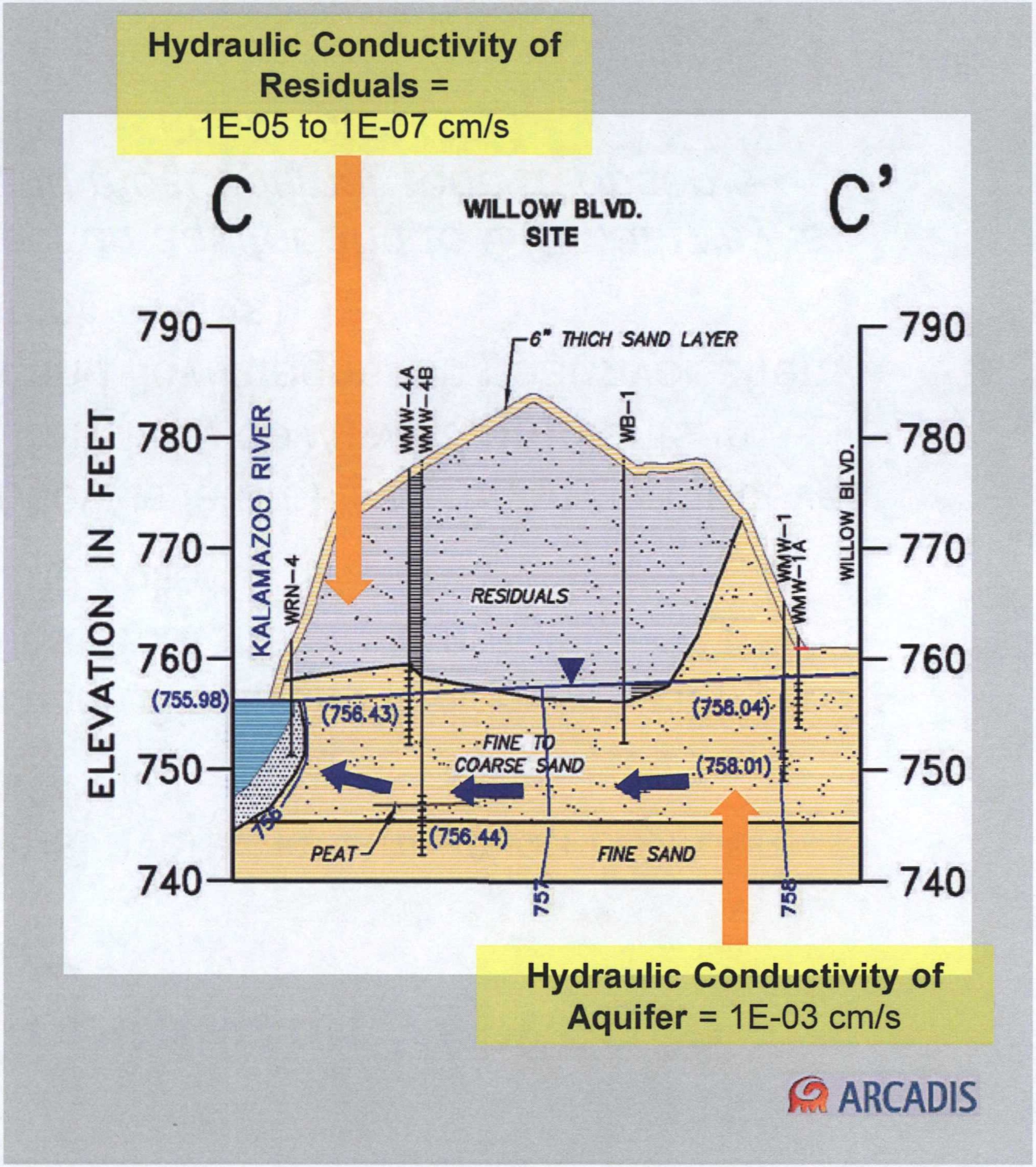
Geologic Cross Section C-C' with GW Flow Net



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WB/A OU Groundwater Venting to Surface Water

- There is minimal hydraulic connection between residuals and aquifer
- Further reduction of infiltration will occur with placement of cap materials and grading – water will be shed and collected
- Groundwater flow is lateral toward the river above silt unit (with transitory downward gradients in upland areas and flow stagnation near river after precipitation/melt events)

➢ *Potential effect on aquifer and to GSI pathway is* de minimis, *and most optimal zone to observe effects is shallow – near water table*

Modeled PCB Flux in Groundwater

- Hydraulic conductivity of 1.5×10^{-3} cm/s (4.9×10^{-5} ft/s)
- Hydraulic gradients ranging from 0.0029 to 0.010 ft/ft
- River flow of 575 cfs
- Average groundwater PCB concentration of 0.042 µg/L
- Upstream river PCB concentration of 0.001 µg/L

Parameter	Groundwater Discharge Area[1]			Hydraulic Conductivity (k) (ft/sec)	Hydraulic Gradient (i) (ft/ft)[2]	Groundwater Flow (Qp) (cfs)	Design Stream Flow (Qs) (cfs)[3]	Dilution Ratio (Qs/Qp)	Avg GW Conc. (ug/l)[4]	Upstream Conc. In River (ug/l)	Final Conc. In River (ug/l)[5]	Avg GW PCB Load (kg/yr)
	Length (ft)	Depth (ft)	Area (sq ft)									
Min gradient	3,000	15	45,000	0.000049	0.0029	0.0064	575	89,537	0.042	0.001	0.0010005	**0.00024**
Avg observed gradient	3,000	15	45,000	0.000049	0.0040	0.0089	575	64,915	0.042	0.001	0.0010006	**0.00033**
Max observed gradient	3,000	15	45,000	0.000049	0.010	0.022	575	25,966	0.042	0.001	0.0010016	**0.00083**

Notes

Worksheet derived from MDEQ Operational Memorandum RRD-5, Attachment 1 - Request to MDEQ for Mixing Zone-Based GSI Criteria (http://www.michigan.gov/documents/deq/deq-rrd-OpMemo_5_Form_286639_7.pdf).

[1]Estimated groundwater discharge area to Kalamazoo River.

[2]Based on groundwater and surface water elevation monitoring, as presented in Figures 13A through 13C of RI/FFS report.

[3]Based on Comstock gage station data; lowest mean monthly discharge rate.

[4]Average calculated using 1/2 detection limit for those samples that were non-detect for PCBs. Groundwater samples from November-December 2000.

[4]Average surface water PCB concentration MDEQ 2011 LTM data at River Street.

PCB Flux in Groundwater

- Average final instream PCB concentration is 0.0010006 µg/L, comprised of:
  - 0.0010000 µg/L from upstream
  - 0.0000006 µg/L from groundwater
- Groundwater component is 2-3 orders of magnitude lower than Rule 57 surface water quality criteria of 0.00012 µg/L (WV) and 0.000026 µg/L (HCV), and 3 orders of magnitude lower than reporting limit of 0.001 µg/L
- Actual venting concentration likely to be less than this value due to conservative assumption that PCBs are present at one-half reporting limit for those samples that were non-detect for PCBs
- Estimated average annual groundwater PCB flux at WB/A-Site OU is 0.00033 kg/yr

➢ ***PCB loading to River from WB/A OU groundwater is*** **de minimis**

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Modeled PCB Flux from River Sediments to Surface Water

Dissolved phase PCB concentration computed using two-phase equilibrium partitioning equation:

$$\text{PCB Flux} = K_f * A * C_{sed} / (f_{oc} * K_{oc}) * 0.001, \text{ where}$$

- K_f is sediment-water mass transfer coefficient (based on literature values)
- A is sediment surface area (calculated as length * width) adjacent to WB/A OU
- C_{sed} is sediment PCB concentration (set at MDEQ detection limit for sediments)
- f_{oc} is sediment fraction of organic carbon in sediment (based on measured values)
- K_{oc} is sediment organic carbon partition coefficient (assumed to be 309,000 [log K_{oc} of 5.5])
- C_{pw} is sediment porewater PCB concentration (calculated as $C_{sed}/(f_{oc}*K_{oc})$)

Sediment-Water Mass Transfer Coefficient (cm/day)	Sediment Surface Area			PCB_{sed} (mg/kg)[1]	f_{oc}	K_{oc} (L/kg)[2]	PCB_{pw} (ug/L)	PCB Flux (kg/yr)
	Length (ft)	Width (ft)	Area (m^2)					
5.0	3,000	175	48,774	0.33	0.019	309,000	0.056	0.050

Notes

[1]MDEQ detection limit for PCBs in sediment.

[2]Koc for PCB from Table 39 of 1996 EPA Soil Screening Guidance.

Comparison of PCB Flux in Sediments and Groundwater

- Flux of PCBs to surface water from sediment adjacent to WB/A OU is calculated to be 0.05 kg/yr (assuming PCB levels in sediments are at the MDEQ detection limit concentration for sediments), compared to 0.00033 kg/yr for groundwater
- Modeled average groundwater flux is <0.7% of flux from sediments

➢ ***PCB flux from groundwater to surface water is negligible relative to potential flux from sediment in River – even assuming sediments are at the MDEQ default detection limit concentration***

Conclusions

Based on existing data and PCB flux modeling, GSI Pathway at WB/A-Site is not relevant

Evolution of groundwater monitoring programs at King Highway, 12th Street Landfill, and former Plainwell Impoundment – along with changes to Part 201 – support a new approach at WB/A-Site

The groundwater monitoring program for WB/A OU will be developed to demonstrate that closure is effective, fulfills the requirements of the Consent Decree, and complies with Part 201

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Recommended Approach for Groundwater Monitoring at Willow Blvd/A-Site OU

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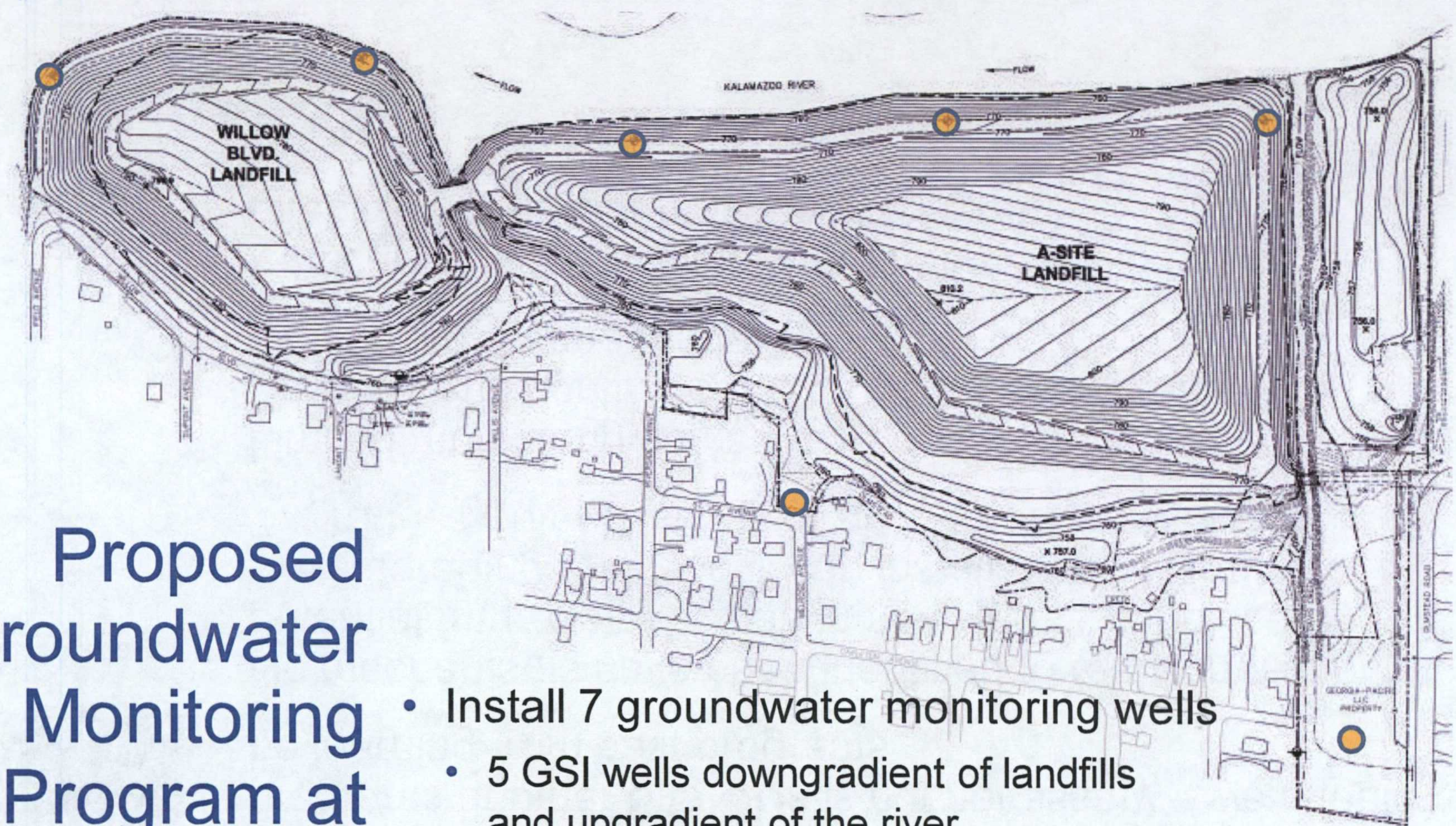
Summary Basis for Proposed Approach at WB/A-Site

- Groundwater monitoring for long-term is not required during post-closure to comply with Part 201 regulations
  - Compliance is demonstrated using RI data and professional judgment
- Complete consistency with groundwater monitoring programs at other Site OUs is not necessary – we should be learning from past programs
- No mechanisms have been identified to result in higher potential future impact than in near-term post-closure
  - Regrading and landfill cap installation will further reduce potential for infiltration through residuals
- Limited monitoring can support compliance with Part 201 and confirm current understanding based available data and modeling
- Vertical aquifer sampling is not necessary to design effective, compliant monitoring program



Proposed Groundwater Monitoring Program at WB/A-Site:

Wells & Analytes

- Install 7 groundwater monitoring wells
  - 5 GSI wells downgradient of landfills and upgradient of the river
  - 2 wells upgradient of landfills
- Analyze samples for:
  - Analytical: PCBs, arsenic, cyanide, aldrin, bis(2-ethylhexyl)phthalate
  - Field parameters: turbidity, temp, pH, oxidation-reduction potential, specific conductivity

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Proposed Groundwater Monitoring Program at WB/A-Site:

Monitoring

- Sample all wells quarterly
- **After 2 years**: Review analytical results to document effectiveness of remedy
  - If closure is determined to be effective, cease monitoring, or
  - Reduce analytes and monitoring frequency, if appropriate
- **Develop contingency plan**: for potential response activity if groundwater results show unacceptable impact to human health or the environment
- **5-Year Review**: USEPA to assess effectiveness of remedy; if closure determined to be ineffective, follow provisions of Consent Decree

